Claims

1. A method for trimming an engine operating in a steady state so that a plurality of injectors contained therein operate in a pre-selected mode, the method comprising:

determining that a speed and a load of the engine are operating in a steady state;

selecting one of the plurality of injectors;

detecting an operating mode of the selected injector;

recording the operating mode of the selected injector;

sequentially repeating the above processes for each remaining unselected injector;

comparing the recorded operating mode of the selected injector to the pre-selected operating mode to determine which of the selected injectors is not operating in the pre-selected operating mode; and changing the detected operating mode to the pre-selected mode for each of the selected injectors detected to be operating in other than the pre-selected operating mode.

2. A method for trimming an engine in a steady state so that a plurality of injectors contained therein operate in a desired operating mode, the method comprising:

determining that a speed of the engine is operating in a steady state;

detecting an operating mode of one of the plurality of injectors;

comparing the detected operating mode of the one of the plurality of injectors to the desired operating mode to determine if the injector is operating in the desired operating mode; and

changing the detected operating mode to the desired operating mode for the one of the plurality of injectors.

3. The method, as set forth in claim 2, further comprising the step of determining the engine is operating in a steady state load.

4. The method, as set forth in claim 2, further comprising the steps of:

detecting an operating mode of each of the plurality of injectors;

comparing the detected operating mode of each of the plurality of injectors to the desired operating mode to determine which of the injectors is not operating in the pre-selected operating mode; and

changing the detected operated mode to the desired operating mode for each of the plurality of injectors detected to be operating in other than the desired operating mode.

5. The method, as set forth in claim 3, wherein the injector modes of operation include a split mode and a boot mode.

6. The method, as set forth in claim 5, wherein an electronic control module in electrical communication with the engine determines the pre-selected mode by referring to lookup maps.

7. The method, as set forth in claim 6, wherein each injector delivers fuel to a respective cylinder during repeated injection events.

8. The method, as set forth in claim 5, wherein an anchor delay current signal occurs for a portion of each injection event.

9. The method, as set forth in claim 8, wherein the step of determining the operating mode of the selected injector includes the steps of:

establishing a statistical average difference in the volume of fuel delivered between a boot mode and a split mode;

establishing a anchor delay current signal offset;

establishing a steady state volume of fuel delivered by all of the injectors for an injection event;

increasing the anchor delay current signal duration by the predetermined anchor delay current signal offset to cause a new volume of fuel to be delivered by the injectors;

recording the new volume of fuel delivered by the injectors;

computing a difference between the steady state fuel volume and the new fuel volume; and

determining whether the difference between the steady state fuel volume and the new fuel volume is greater than the predetermined statistical average difference in the volume of fuel delivered between a boot mode and a split mode.

10. The method, as set forth in claim 9, wherein the step of recording the operating mode of the selected injector includes the step of recording that the selected injector was operating in the boot mode before increasing the duration of the anchor delay current signal duration if the difference between the steady state fuel volume and the new fuel volume is greater than the predetermined statistical average difference in the volume of fuel delivered between a boot mode and a split mode, and includes the step of recording that the selected injector was operating in the split mode before increasing the duration of the anchor delay current signal duration if the difference between the steady state fuel volume and the new fuel volume is less than the predetermined

statistical average difference in the volume of fuel delivered between a boot mode and a split mode.

11. The method, as set forth in claim 10, wherein the step for altering the operating mode of a selected injector includes the step of altering the duration of the anchor delay current signal by the predetermined anchor delay current signal offset.

12. A fuel injection control system for trimming an engine in a steady state so that a plurality of injectors contained therein operate in a pre-selected mode, the apparatus comprising:

an engine speed sensor;

an engine load sensor;

an electronic control module in electrical communication with the engine speed sensor and the engine load sensor;

wherein the electronic control module is operable, upon determining that the engine speed and load are in a steady state, to select a previously unselected injector; to determine the operating mode of the selected injector; to record the operating mode of the selected injector; to sequentially repeat the operations of selecting a previously unselected injector; to determine the operating mode of the selected injector and record the operating mode of the selected injector for each of the plurality of injectors; to compare the recorded operating mode of each injector to the pre-selected operating mode to

determine which of the selected injectors is not operating in the pre-selected operating mode; and to change the detected operating mode to the pre-selected mode for each of the injectors determined to be operating in other than the pre-selected operating mode.

13. The fuel injection control system, as set forth in claim 12, wherein the injector modes of operation include a split mode and boot mode.

14. The fuel injection control system, as set forth in claim 13, wherein the electronic control module determines the pre-selected mode by referring to lookup maps.

15. The fuel injection control system, set forth in claim 14, wherein each injector delivers fuel to a respective cylinder during repeated injection cycles.

16. The fuel injection control system, as set forth in claim 15, wherein an anchor delay current signal occurs for a portion of each injection event.

17. The fuel injection control system, as set forth in claim 16, wherein the electronic control module determines the operating mode of the selected injector by recording a predetermined statistical average difference in the volume of fuel delivered

between a boot mode and a split mode; recording a predetermined anchor delay current signal offset; recording a steady state volume of fuel delivered by all of the injectors for an injection event; increasing the anchor delay current signal duration by the predetermined anchor delay current signal offset to cause a new volume of fuel to be delivered by the injectors; recording the new volume of fuel delivered by the injectors; computing a difference between the steady state fuel volume and the new fuel volume; and determining whether the difference between the steady state fuel volume and the new fuel is greater than the predetermined statistical average difference in the volume of fuel delivered between a boot mode and a split mode.

18. The fuel injection control system, as set forth in claim 17, wherein the electronic control module records the operating mode of the selected injector by recording that the selected injector was operating in the boot mode before increasing the duration of the anchor delay current signal duration if the difference between the steady state fuel volume and the new fuel volume is greater than the predetermined statistical average difference in the volume of fuel delivered between a boot mode and a split mode, and by recording that the selected injector was operating in the split mode before increasing the duration of the anchor delay current signal duration if the difference between the steady

state fuel volume and the new fuel volume is less than the predetermined statistical average difference in the volume of fuel delivered between a boot mode and a split mode.

19. The fuel injection control system, as set forth in claim 18, wherein the electronic control module changes the detected operating mode of a selected injector to the pre-selected mode by altering the duration of the anchor delay current signal by the predetermined anchor delay current signal offset.

20. A method for trimming an engine having at least one injector controllable by an electronic control signal, the engine having an engine speed and load, the method comprising:

detecting an operating mode of each injector.

21. The method, as set forth in claim 20, including the step of modifying the electronic control signal to each injector.

22. The method, as set forth in claim 21, including the step of detecting an operating mode of each injector generated by the modified electronic control signal.

23. The method, as set forth in claim 22, wherein the injector modes of operation include a split mode and a boot mode.

24. The method, as set forth in claim 23, wherein the characteristics of the electronic control signal are determined in accordance with lookup maps associated with the engine.

25. The method, as set forth in claim 24, wherein each injector delivers fuel to a respective cylinder during repeated injection events.

26. The method, as set forth in claim 25, wherein the electronic control signal includes an anchor delay current signal for a portion of each injection event.

27. A method for trimming at least one fuel injection device associated with an engine, the injection device injecting multiple fuel shots in accordance with an electronic control signal generated by the engine during a fuel injection event, the method comprising the steps of:

sensing a first engine speed;

modifying the electronic control signal;

sensing a second engine speed; and

determining an operating mode of the at least one fuel injection device in response to said first and second engine speeds.

28. A method, as set forth in claim 27, wherein the operating modes include a split mode and a boot mode.

29. The method, as set forth in claim 28, wherein each injection device delivers fuel to a respective cylinder during repeated injection events, the injection event including a first injection and a second injection and an injection delay between the first and second injections.

30. The method, as set forth in claim 29 wherein the step of modifying the electronic control signal further comprises the step of modifying the injection delay.

31. The method, as set forth in claim 29, wherein the step of modifying the electronic control signal further comprises the step of increasing the injection delay by a predetermined amount.

32. The method, as set forth in claim 29, wherein the step of determining the operating mode of said first and second engine speeds further comprises the steps of

determining a difference between said first and second engine speeds; and

determining the operating mode is a split injection mode when said difference is less than a predetermined threshold.

33. The method, as set forth in claim 29, wherein the step of determining the operating mode of said first and second engine speeds further comprises the steps of

determining a difference between said first and second engine speeds; and

determining the operating mode is a boot injection mode when said difference is greater than a predetermined threshold.